

## Finite Element Analysis of Piezoelectric Energy Harvester

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Woo Seok Hwang

1.

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$$\begin{Bmatrix} \sigma \\ D \end{Bmatrix} = \begin{bmatrix} c^E & -e^T \\ e & \epsilon^s \end{bmatrix} \begin{Bmatrix} \epsilon \\ E \end{Bmatrix} \quad (1)$$

Hamilton

$$\delta \int_{t_1}^{t_2} [T - U + W] dt = 0 \quad (2)$$

$$D_3 = e_{31}\epsilon_1 + e_{32}\epsilon_2 + e_{36}\gamma_{12} + \epsilon_{33}^s E_3 \quad (3)$$

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Richard

$$\begin{aligned} q(t) &= \int_A D_3 dA \\ &= \int_A e_{33} \kappa dA + \int_A \epsilon_{33}^s E_3 dA \\ &= \int_A L^T \kappa dA + \epsilon_{33}^s A E_3 \end{aligned} \quad (4)$$

3.

Fig.1 4- , 12-

$r^e$

2.

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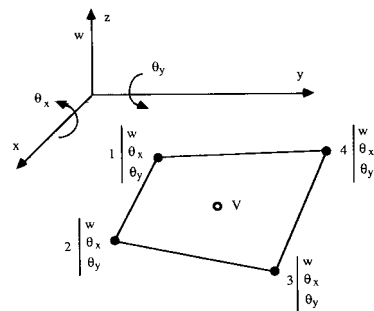


Fig.1 4 node plate element with electric D.O.F.

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E-mail : whwang@daegu.ac.kr  
Tel : (053) 850-6672, Fax : (053) 850-6689

$$r^e = \{w_1 \theta_{x1} \theta_{y1} w_2 \theta_{x2} \theta_{y2} w_3 \theta_{x3} \theta_{y3} w_4 \theta_{x4} \theta_{y4}\}^T \quad (5)$$

$$\theta_y (= \partial w / \partial x) \quad x \quad y$$

$$v \quad \kappa \quad (2)$$

$$v = \Psi_v r^e \quad (6)$$

$$\kappa = \Psi_\kappa r^e$$

$$M^e \ddot{r}^e + K^e r^e = F^e + \Theta^e V^e \quad (7)$$

$$M^e = \int_{-1}^1 \int_{-1}^1 \Psi_v^T R \Psi_v |J| d\xi d\eta$$

$$K^e = \int_{-1}^1 \int_{-1}^1 \Psi_\kappa^T D \Psi_\kappa |J| d\xi d\eta \quad (8)$$

$$F^e = \int_{-1}^1 \int_{-1}^1 \Psi_v^T f |J| d\xi d\eta$$

$$\Theta^e = \frac{1}{t^P} \int_{-1}^1 \int_{-1}^1 \Psi_\kappa^T L |J| d\xi d\eta \quad (4)$$

$$q(t) = [\Theta^e]^T r^e \quad (9)$$

$$i(t) = \frac{dq(t)}{dt} = [\Theta^e]^T \dot{r}^e \quad (10)$$

$$i(t) = \frac{V^e}{R} \quad \text{가}$$

$$V^e = R [\Theta^e]^T \dot{r}^e \quad (11)$$

4.

Fig.2

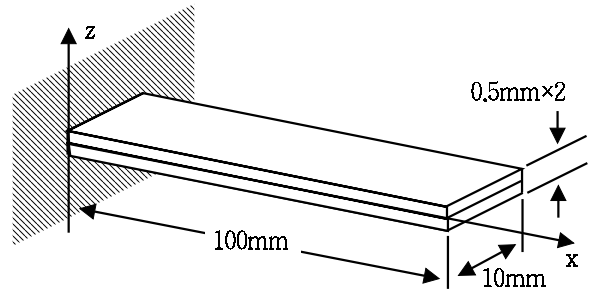


Fig.2 Piezoelectric PVDF Bimorph Beam

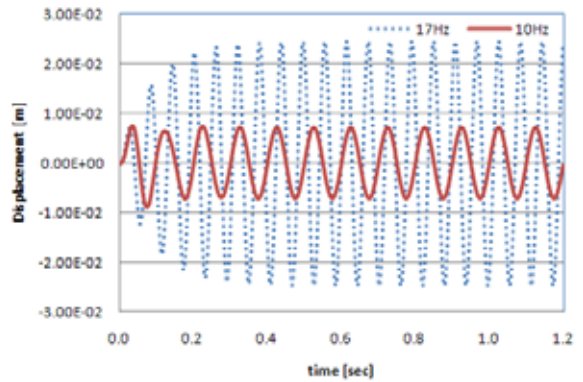


Fig.3 Tip displacement

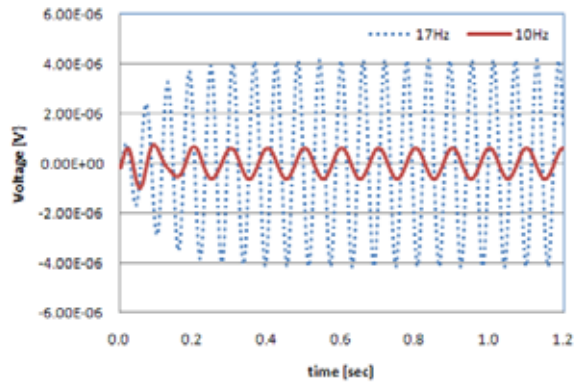


Fig.4 Output voltage

4.

가 17.24Hz  
 가 0.01m 가 10Hz 17Hz  
 가  
 Fig.4 10Hz 가  
 가 가 0.01m  
 17Hz 가 가